U.S. Department of Energy
Carbon Sequestration Program

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Carbon Capture and Sequestration :

Capture-Ready Requirements and Benefits: A Possible Step Forward to Carbon Dioxide Abatement

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National Energy Technology Laboratory

Outline

- What is a Capture Ready Power Plant ?
- Capture Technology Developers Provide Guidance
- Overview of Capture-Ready Discussions
- U.S. CO_2 Capture Market
- Should Capture-Ready be considered?
- Closing Thoughts

What is a Capture-Ready Power Plant?

What is "CO_2 Capture Ready" ?

- **There is no one agreed upon definition.**
- **Easy Requirements:**
  - **Space on site and in critical access locations to build CO_2 capture plant and make connections.**
  - **Design study for adding CO_2 capture.**
- **Challenging Requirements:**
  - **Optional pre-investments to reduce future costs, improve performance, etc.**
    - **Extra/modified equipment**
    - **Plant siting to reduce sequestration costs**
    - **Choice of base plant**

Jon Gibbins, et al., *Capture Ready Fossil Fuel Plants: definitions, technology options, and economics*, 2006.

Statoil/Shell 860 MW NG power plant, Draugen,Norway

Jon Gibbins, et al., *Capture Ready Fossil Fuel Plants: definitions, technology options, and economics*, 2006.

Generic Requirements for Retrofit and Greenfield Capture-Ready Application

MINIMIZE COST BUT
PERFORM AS MUCH AS POSSIBLE
DURING PLANNED OUTAGES

- **Perform an engineering feasibility study**
  - Involve Boiler, ASU and Turbine manufacturers
  - Estimate planned outage schedule with and without Capture-Ready
  - Communicate with Permitting Authorities
- **Identify existing or procure land requirements for CO_2 Capture and compression on-site**
- **Identify a CO_2 market, either sale or disposal, in proximity of the power plant**
- **Improve or specify the most efficient power plant equipment to minimize the parasitic energy loss associated with CCS**
- **Develop new power plant CCS operating procedures**
- **Identify how the plant shall maintain power/grid parity with CCS implementation**

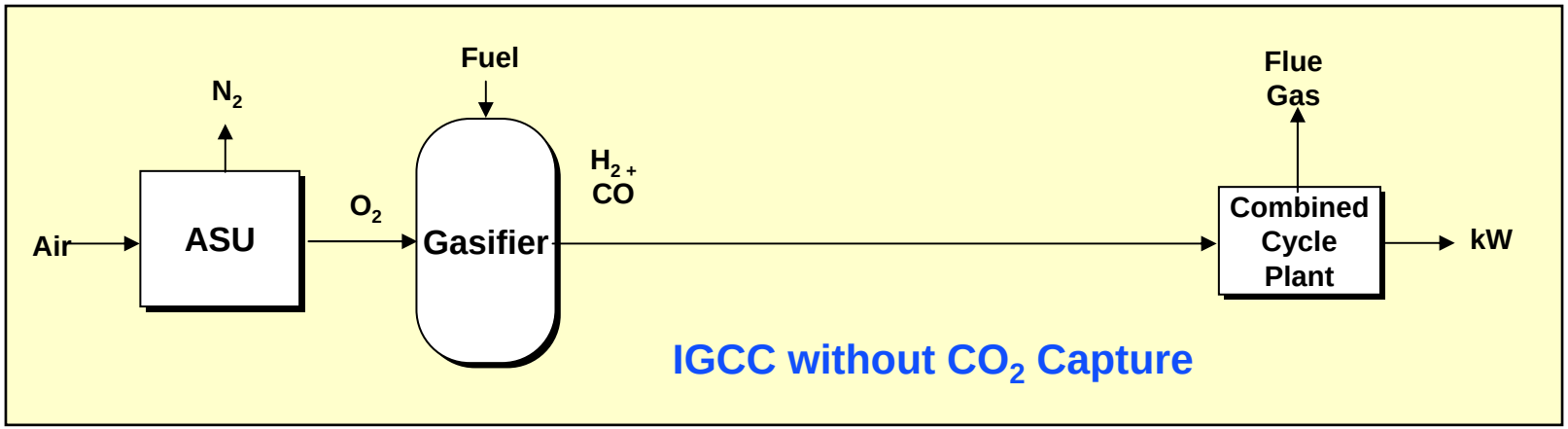
Technology Developers Provide Guidance

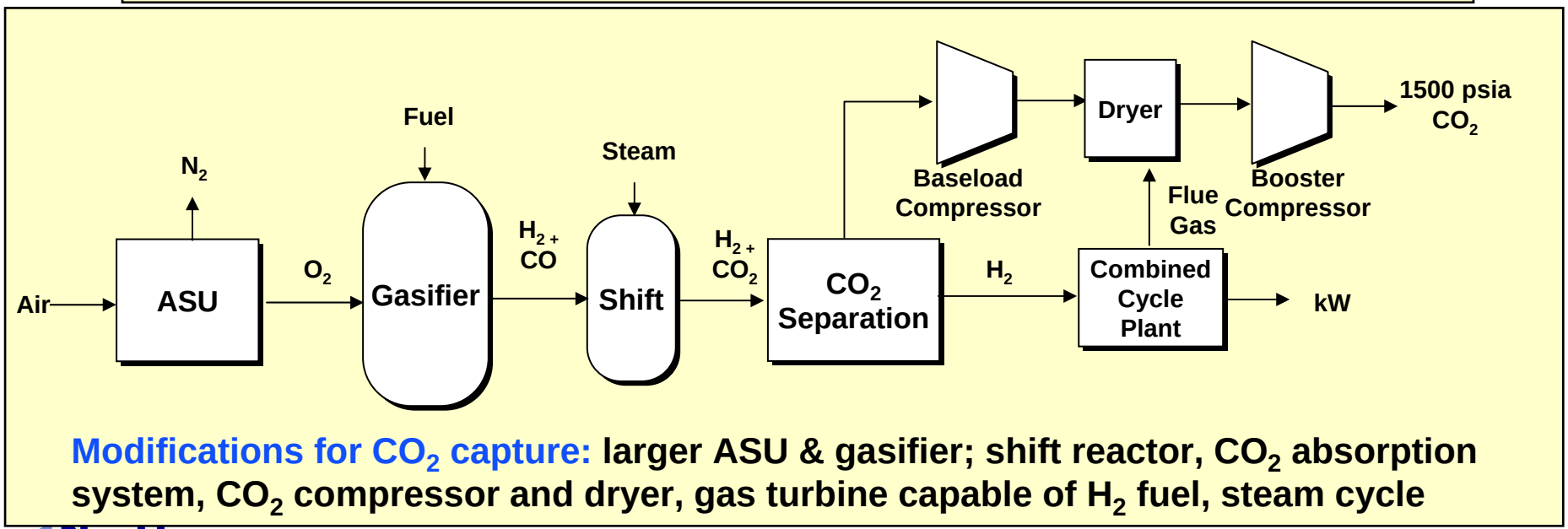
- **Oxycombustion:**
  - Burners designed for air and oxygen firing
  - Air and Oxygen operation
    - Boiler design flexibility
    - Optimize air heater design
  - Minimize air infiltration to reduce purification step
  - Optimize fans for recycled flue gas
  - Space requirements needed for recycle ductwork
  - WFGD enhancement designed or retrofitted for additional SO_2 control, if needed.

Technology Developers Provide Guidance

- **Post Combustion:**
  - **VERY PLANT AND TECHNOLOGY SPECIFIC**
    - Engineering feasibility study required for technology selection based on site specific criteria
  - Availability of real estate for future retrofit of capture technology
  - Design or retrofit for piping and control system routing as needed
  - Turbine steam extraction provisions identified
    - Implementation is optional
  - Design or retrofit for additional fan requirements due to increased pressure drop in the flue gas pathway
  - WFGD enhancement designed or retrofitted for additional SO_2 control, if needed.

Technology Developer Provides Guidance Pre-combustion





Modifications for CO_2 capture: larger ASU & gasifier; shift reactor, CO_2 absorption system, CO_2 compressor and dryer, gas turbine capable of H_2 fuel, steam cycle

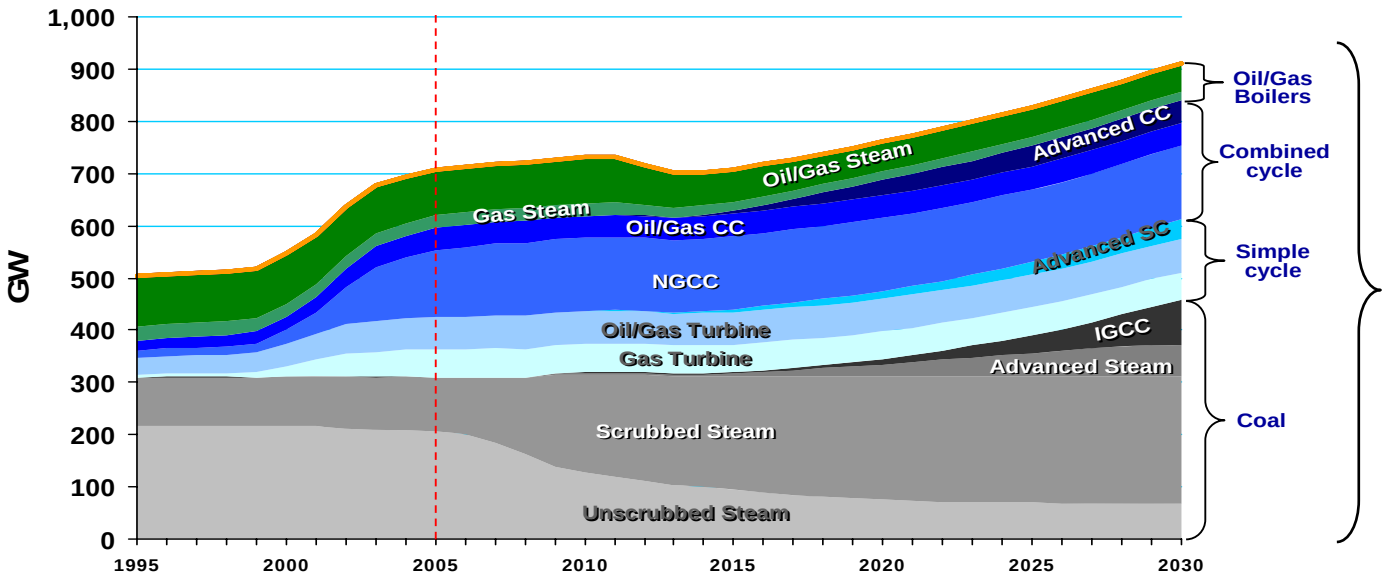
Source: Praxair

Capture-Ready Discussions

- **Three Camps: Against, For and Undecided**
- **Against:**
  - No benefit in Capture-Ready indicated by Some researchers:
    - No regulations mandating CO_2 environmental control
    - Time value of money does not justify capture ready application
    - Future CO_2 capture technologies improvements warrant a wait and see approach
- **For:**
  - Benefits exist if you look beyond the plant fence line
- **Undecided:**
  - Generally confused on a course of action due to a lack of clear Capture-Ready definition.
    - A definition may not be possible due to the number of variables associated with Government, Corporate, NGO and Individual perspectives associated with the Capture-Ready Concept

What is the CO_2 Capture Market ?

- **Total 9,877 units installed in the U.S.**
  - 337 GW of coal-fired units
  - 422 GW of gas-fired units
  - 64 GW of oil-fired units
- **423 existing coal-fired power plants**
  - Comprised of 1,089 boiler units
  - Generate 323 GW (Phase 1&2)
  - Emit 1,917.2 million metric tons of CO_2

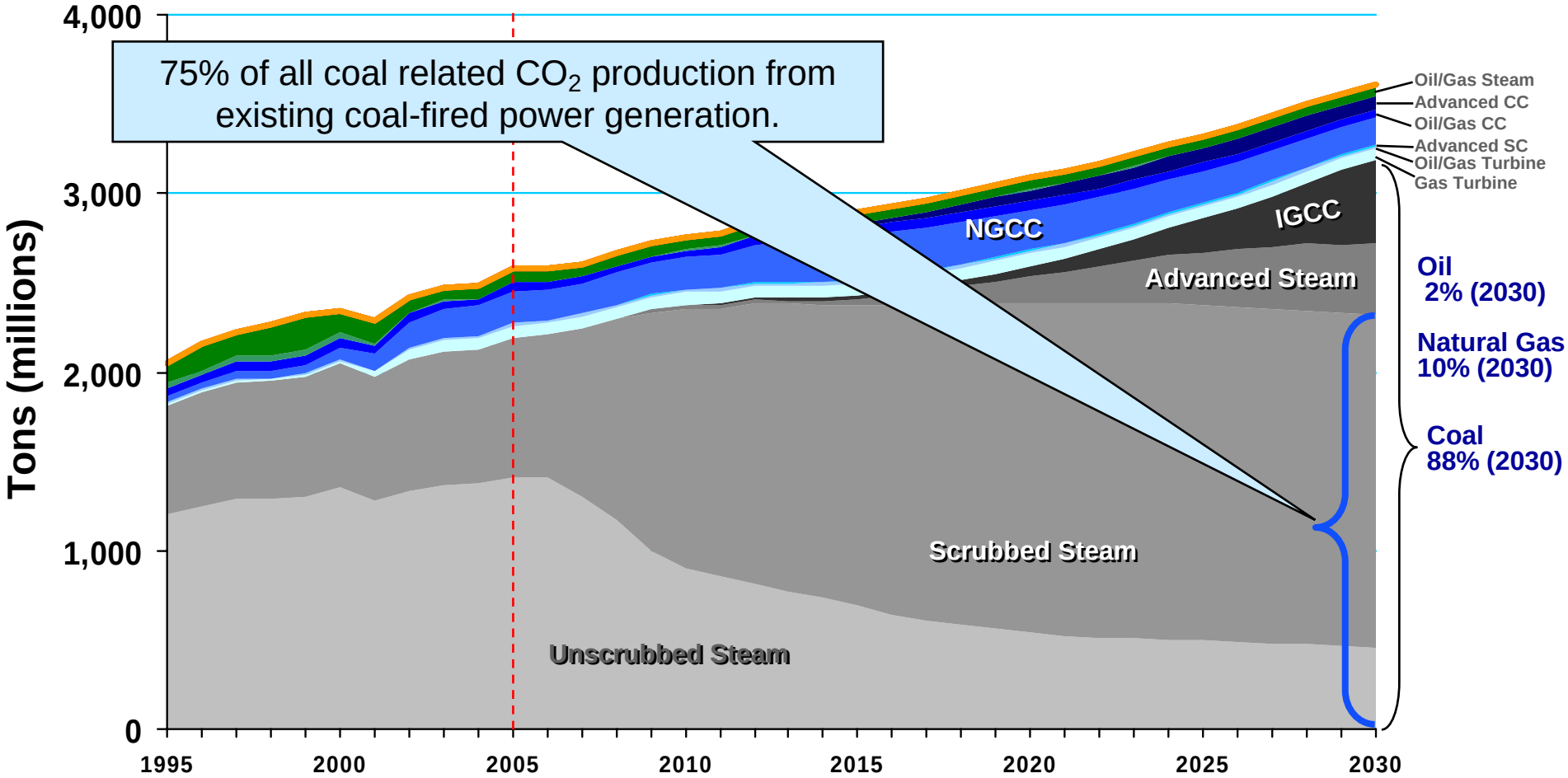


Fossil Power Generation Technology Types

The market potential for capture-ready is significant and dependant on regulations and corporate environmental stewardship ?

Source: EIA, UDI, EPA

What is the CO_2 Capture Market ?



Coal Dominates CO_2 Emissions From Fossil Power Generation As Percent of Coal-fired Generation Grows to 59% (2030)

Why the Need to Consider Capture-Ready Implementation

Energy Penalty due to CO_2 Capture	10%	20%	30%	40%
Target Market, GW	184	184	184	184
Fleet CO_2 Reduction, %	50.2	49.2	47.9	46.3
New Capacity Req'd, GW	25.5	57.5	98.5	153.3
Additional Coal Req'd., tons x 10^3	79,940	179,864	308,338	479,637
Cost of New Capacity, MM$	45,975	103,444	177,332	275,850
Cost of CO_2 Retrofits, MM$	91,950	91,950	91,950	91,950
Total New Cost, MM$	137,925	195,394	269,282	367,800

Current Energy Penalty of CO_2 BACT MEA Absorption System

Should Capture-Ready Be Considered?

“Capture Ready” Approach

- **Existing and Greenfield power plants could be made capture ready by:**
  - determining the requirements to meet the status of “Capture Ready”,
  - perform only the necessary modifications to accept a CO_2 capture system over one or several planned outages.
  - Verification of capture-ready status through an auditable process

- **Benefits:**
  - This approach could minimizes the need for an extended costly outage during implementation.
  - Should CO_2 regulations be enacted:
    - Technology Developers and Plant Manufacturers are more likely to meet the needs of those plants that are capture ready to their type of technology.
  - Reduces the potential CO_2 liability risk due to the Sarbanes-Oxley Act of 2002
  - Potentially increases the opportunity for market analyst ratings to be higher
    - Due to a corporate approach to mitigating their CO_2 liability risk over others in the sector that are not.

There are externalities associated when considering if capture ready can meet your needs. Consider them all before deciding.

Closing Thoughts

CO_2 Capture Ready

CO_2 Capture Deployed

"Carbon Lock In"

Acknowledgements

- Alstom Power
- Babcock & Wilcox Corporation
- Imperial College – UK
- Praxair
- Research Triangle Institute International

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Technologies
Carbon Sequestration

NETL manages a portfolio of laboratory and field R&D focused on technologies with great potential for reducing greenhouse gas emissions and controlling global climate change. Most efforts focus on capturing carbon dioxide from large stationary sources such as power plants, and sequestering it using geologic, terrestrial ecosystem, or oceanic approaches. Control of fugitive methane emissions is also addressed.

Carbon sequestration work directly implements the President's Global Climate Change Initiative, as well as several National Energy Policy goals targeting the development of new technologies. It also supports the goals of the Framework Convention on Climate Change and other international collaborations to reduce greenhouse gas intensity and greenhouse gas emissions.

The programmatic timeline is to demonstrate a portfolio of safe, cost effective greenhouse gas capture, storage, and mitigation technologies at the commercial scale by 2012, leading to substantial deployment and market penetration beyond 2012. These greenhouse gas mitigation technologies will help slow greenhouse

NEWS & FEATURES // All >

- Carbon Sequestration Technology Roadmap [PDF-4542KB]
- Carbon Sequestration Program Outreach Plan [PDF-1438MB]
- DOE-Advances Commercialization of Climate Change Technology
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EVENTS CALENDAR // All >

- The 2006 EIC Climate Change Technology Conference - Engineering Challenges and Solutions in the 21st Century

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- Carbon Sequestration Reference Shelf
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http://www.netl.doe.gov/technologies/carbon_seq/index.html

Questions ?

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